Gear shifting system

Technical Field of the Invention

5   The present invention relates to a method for determining a vehicle speed, e.g. for an automatic gear shifting system. The invention also relates to a vehicle with a gearbox, a computer program for determining the vehicle speed, a computer program product and an electronic control unit comprising the computer program.

Background of the invention

An automatic gearbox for a vehicle is typically controlled by an ECU (electronic control unit), which controls gear selection so as to achieve an engine operation considered appropriate. A number of parameters may be considered when determining an initiation of gear change. Such parameters suitably comprises the vehicle speed, which is calculated as a function of e.g. the speed of a propeller shaft for the driven wheels. A method and apparatus for automatically controlling gear selection, wherein the speed of the propeller shaft is measured is described in US-6480776-B 1. An alternative known in the art for calculating the vehicle speed for determination of a gear change utilises a sensed value of the engine speed or the crankshaft speed in combination with a current gear ratio between the speed of a gearbox input shaft and a gearbox output shaft/propeller shaft. Another alternative would be to utilise the rate of rotation of the wheels, which may be retrieved from wheel speed sensors adjacent to the each one of the wheel respectively. However, processed signals from such wheel-speed sensors are generally inferior to the quality provided by a speed sensor for e.g. the propeller shaft and are therefore not used when calculating the vehicle speed.

A modern vehicle is often equipped with a TCS (traction control system) and an ABS (Antilock braking system), which typically comprises wheel-speed sensors and an ABS/TCS ECU. The ABS/TCS ECU is responsible for controlling a wheel brake when the ABS/TCS ECU detects incipient lockup of a corresponding wheel. The

ABS/TCS ECU also controls the wheel brake for a driven wheel which shows a tendency to spin and/or adapts the engine torque to a drive torque which can be transferred to the road, so that the vehicle retains its stability.

5   Especially when driving on smooth or slippery roads on a gradient or when cornering, the driven wheels may spin. The TCS is therefore activated. Due to the spinning driven wheels and the braking controlled by the ABS/TCS ECU, a calculated value of the vehicle speed based on the propeller shaft speed or any of its alternatives mentioned above is not accurate relatively to the real vehicle speed. Since the calculated value is
10   used as an input parameter to an ECU for automatic gear changing, this ECU may initiate a gear change based on an erroneous vehicle speed. A gear upshift of at least one gear step may thus occur when driving uphill, which may cause inconvenience for the driver as well as disturbing queues of other vehicles behind the vehicle. This is especially true if the vehicle is a heavy vehicle, such as a truck or bus, which generally
15   has a longer acceleration time than an ordinary car.

On e.g. a tractor and semi-trailer eqipage, the tractor has a front wheel axle and a rear wheel axle, wherein the rear wheel axle is the driving axle. During a retarding motion, the front wheel axle is exerted to a higher force than the rear wheel axle. Therefore
20   while braking, incipient lockup of the driven wheels occurs earlier and more often than the non-driven wheels on the front wheel axle. Incipient lockup of the rear wheels before lockup of the front wheels naturally occurs also for vehicles having all wheels driven. Hence the ABS system controls the braking of the rear wheels more actively than the braking of the front wheels. The involvement of the ABS system also disturbs
25   the accuracy of the calculated value of the vehicle speed, since the propeller shaft speed or any of its alternatives is affected by the ABS system. Thus a similar problem to the one described above regarding a gear change when the driven wheels are spinning may arise also when the ABS controls the wheel brakes.

30   Summary of the invention

It is an object of the invention to avoid or at least decrease the number of incorrect automatic gear changes when a vehicle is braked by an ABS or a wheel is spinning.

5   The invention relates to a method for determining a vehicle speed, e.g. for an automatic gear shifting system. The method comprises the steps of:
- determining if at least one driven wheel is spinning or shows a tendency to spin and/or if the vehicle is braked under influence of an ABS, and
- determining the vehicle speed based on a rate of rotation of at least one non-driven
10   wheel, a value of the vehicle speed received from a positioning system and/or a value of the vehicle speed received from a vehicle radar system, if either the at least one driven wheel is spinning or shows a tendency to spin or the vehicle is braked under influence of the ABS.

Hereby is achieved that the vehicle speed is determined by means previously not used
15   by ,e.g., an automatic gear shifting system for vehicle speed determination, since the vehicle speed value received from these means normally is considered as poor compared to a vehicle speed value based on a propeller shaft speed. The vehicle speed value based on the propeller shaft is however discovered as being inaccurate compared to the value received from these means when the vehicle is braked under the influence
20   of an ABS and e.g. a TCS. Hence a better estimation of the vehicle speed is achieved when the vehicle is affected by an ABS and e.g. a TCS.

According to one embodiment, the method comprises the step of:
calculating the vehicle speed based on an engine speed, a propeller shaft speed and/or
25   a crank shaft speed, if the at least one driven wheel is not spinning or shows a tendency to spin or the vehicle is not braked under the influence of the antilock braking system. Hereby is achieved that calculation of the vehicle speed is either based on an engine speed, a propeller shaft speed and/or a crank shaft speed, or based on a rate of rotation of at least one non-driven wheel, a value of the vehicle speed received
30   from a positioning system and/or a value of the vehicle speed received from a vehicle radar system.

The invention also relates to a vehicle, e.g. a truck or a bus. The vehicle comprises

- an automatic gear shifting system,

- a system for determining if at least one driven wheel is spinning or shows a tendency

to spin and/or an antilock braking system, and

- calculation means for calculating a vehicle speed based on a rate of rotation of at

least one non-driven wheel, a positioning system unit and/or a vehicle radar system,

- and determining means for determining the vehicle speed based on a rate of rotation

of at least one non-driven wheel, a value of the vehicle speed received from the

positioning system unit and/or a value of the vehicle speed received from the vehicle

radar system, if either the at least one driven wheel is spinning or shows a tendency to

spin or the vehicle is braked under influence of the antilock braking system.

The vehicle may comprise calculating means for calculating the vehicle speed based

on an engine speed, a propeller shaft speed and/or a crank shaft speed, if the at least

one driven wheel is not spinning or shows a tendency to spin or the vehicle is not

braked under the influence of the antilock braking system.

The invention also relates to a computer program for determining a vehicle speed, e.g.

for automatic gear shift control. The computer program comprises computer readable

code means, which when run on an electronic control unit in a vehicle causes the

electronic control unit to

- determine if at least one driven wheel is spinning or shows a tendency to spin and/or

if the vehicle is braked under influence of an antilock braking system, and

- determine the vehicle speed based on a rate of rotation of at least one non-driven

wheel, a value of the vehicle speed received from a positioning system and/or a value

of the vehicle speed received from a vehicle radar system, if either the at least one

driven wheel is spinning or shows a tendency to spin or the vehicle is braked under

influence of the antilock braking system.

Furthermore the invention relates to a computer program product comprising a computer readable medium and the computer program stored on the computer readable medium.

5   Moreover the invention relates to an electronic control unit adapted for connection to a vehicle internal network bus in a vehicle, comprising a storing means and the computer program stored on the storing means.

In one embodiment the electronic control unit is a gearbox electronic control unit.

10 Hereby is achieved that the gearbox electronic control unit itself determine the vehicle speed.

Brief Description of the Drawings

15 The objects, advantages and effects as well as features of the present invention will be more readily understood from the following detailed description of a method and a vehicle, as well as other embodiments, when read together with the accompanying drawings, in which:

Fig. 1 schematically shows a vehicle according to the invention,

20 Fig 2 schematically shows an ECU according to the invention, and

Fig 3 is a flow diagram of an embodiment of a method according to the invention.

Detailed Description of Embodiments

25 While the invention covers various modifications and alternative constructions, embodiments of the invention are shown in the drawings and will hereinafter be described in detail. It is to be understood, however, that the specific description and drawings are not intended to limit the invention to the specific forms disclosed. On the contrary, it is intended that the scope of the claimed invention includes all

30 modifications and alternative constructions thereof falling within the spirit and scope of the invention as expressed in the appended claims.

Fig. 1 shows a schematic block diagram of a vehicle 1, such as a bus and a truck, comprising a motor 2 for propelling the vehicle, such as an internal combustion engine, a hybrid motor and an electric motor. The motor 2 is connected to an input
5   shaft for a gearbox 3 via a clutch arrangement 4. A motor torque is thus transmitted to a propeller shaft 5 via the gearbox 3 and the propeller shaft 5 further transmits the motor torque to rear, driven wheels 6 via a differential 7 and corresponding half shafts 8. The vehicle 1 also comprises at least one front axle 9 with at least two non-driven wheels 10. A motor ECU 11 is arranged for controlling the motor 2, a gearbox ECU 12
10   is arranged for controlling inter alia the clutch arrangement 4 and the gearbox 3 and an ABS/TCS-ECU 13 is arranged for controlling the wheel brakes (not shown) for each one of the driven wheels 6 and non-driven wheels 10. The motor ECU 11, the ABS/TCS-ECU 13 and the gearbox ECU 12 are able to communicate with each other via a vehicle internal network bus 14, e.g. a bus compatible with CAN (Controller
15   Area Network), TTCAN (Time-triggered Controller Area Network) and/or FlexRay. The ABS/TCS-ECU 13 belongs to an ABS and a TCS, wherein the TCS can be said to be an extension of the ABS in the sense that the TCS comprises the same hardware as the ABS: wheel-speed sensors 15 for each one of the wheels, the wheel brakes and an hydraulic modulator (not shown) located between the ABS/TCS-ECU 13 and the
20   wheel brakes. The hardware and software of the ABS and TCS as well as their functions are known to a person skilled in the art and are therefore not described more in detail.

At least one speed sensor 16 for sensing the speed of rotation of the propeller shaft 5 is
25   in this embodiment connected to the gearbox ECU 12. The purpose of the speed sensor 16 is to receive a value used by the gearbox ECU 12 to calculate a vehicle speed. The vehicle speed is then used as an input parameter in a calculation to determine if an automatic gear change shall be initiated by the gearbox ECU 12. Different calculation methods involving the vehicle speed for determining if an automatic gear change shall
30   be initiated are known to a person skilled in the art and are not as such part of this invention. Such calculation methods are therefore not described more in detail. The

speed sensor 16 may of course be connected to another ECU than the gearbox ECU 12 as long as the gearbox ECU 12 is able to retrieve the value, e.g. via the vehicle internal network bus 14. The calculation of the vehicle speed is according to the invention also not limited to be processed by the gearbox ECU 12, but may be processed by another

5   ECU, such as the ABS/TCS-ECU 13, directly or indirectly connected to the vehicle internal network bus 14. Although not shown in any drawings, instead of arranging the speed sensor 16 adjacent to the propeller shaft 5, the speed sensor may be positioned for sensing the speed of rotation of a fly wheel, a crankshaft, an apparatus directly driven by the motor 2, such as an alternator, and/or the input shaft for the gearbox. A

10   calculation of the vehicle speed based on the speed of rotation for these three elements are similar to the calculation based on the speed of rotation of the propeller shaft 5 and is known to a person skilled in the art.

The vehicle 1 may receive positioning data from a positioning system in order to, inter

15   alia, determine a geographical position and velocity/speed of the vehicle 1. Examples of positioning systems are GPS (Global Positioning System), differential GPS, Glonas, Orbcomm and Gallileo. The use of positioning systems for determining a vehicle position is in itself known in the art, and will therefore not be described in detail. In the embodiment shown in Fig 1, a positioning system unit in the form of a GPS signal

20   receiving and processing unit is connected to the vehicle internal network bus 14, but may be comprised in the gearbox ECU 12 or any other ECU connected to the vehicle internal network bus 14. The GPS signal receiving and processing unit is in this embodiment adapted to calculate an instantaneous speed for the vehicle based on the received signals from satellites and, in case of a differential GPS, base stations. Such a

25   receiver and processing unit are known to a person skilled in the art and is therefore not described in detail. Alternatively this calculation of the vehicle speed may be performed by the gearbox ECU 12 or any other ECU based on the signals received from the satellites and base stations.

30   The vehicle also comprises a vehicle radar system 18, which is as such known in the art, connected to the vehicle internal network bus 14. Such a vehicle radar system 18

may be utilised by e.g. ACC-systems (Adaptive cruise control systems) and the vehicle radar system 18 also calculates a vehicle speed.

An example of an ECU according to the invention, in this embodiment the gearbox
5   ECU 12, is schematically disclosed in Fig. 2. The gearbox ECU 12 here comprises a processing means 19 connected to a first port 201 in order to enable communication with other ECUs, such as the ABS/TCS-ECU 13 via the vehicle internal network bus 14, a second port 202 for communications with actuator means (not shown) for the clutch arrangement 4, a third port 203 for communication with actuator means (not
10   shown) for the gearbox 3, and a fourth port 204 for receiving signals from the speed sensor 16. The processing means is also connected to at least one computer program product in the form of a storing means 21, such as a hard disk, a flash memory, a ROM (Read-only memory), an EPROM (Erasable Programmable ROM) or an EEPROM (Electrically Erasable Programmable ROM). The storing means in this embodiment
15   comprises inter alia a computer program for gear shift control. This computer program comprises determining means in the form of a computer program (programme module) for determining a vehicle speed 22 and calculating means in the form of a computer program for vehicle speed calculation 23. In accordance with what is said above in conjunction with Fig 1, the computer program for vehicle speed calculation 23 is as
20   such known in the art and may alternatively or in addition be installed in another ECU connected to the vehicle internal network bus 14.

Having described embodiments of a system and a vehicle, some embodiments of a method according to the invention will now be described in conjunction with Fig 3. In
25   a first step S1, the gearbox ECU 12 receives signal/data from the speed sensor 16 and the ABS/TCS-ECU 13. The data from the ABS/TCS-ECU 13 comprises a value of the rate of rotation for each one of the wheels, 6 and 10 respectively, and indicators showing whether the TCS or the ABS is currently controlling the wheel brakes. A value of the vehicle speed may according to another embodiment of step S1 also be
30   received from the GPS signal receiving and processing unit in addition to or instead of the value of the rate of rotation for each one of the wheels from the ABS/TCS-ECU

13. This vehicle speed may according to yet another embodiment of step S1 be retrieved from the vehicle radar system 18, instead of or in addition to the values of the vehicle speed received from the ABS/TCS-ECU 13 and the GPS signal receiving and processing unit.

In a second step S2, the computer program for gear shift control 22 causes the gearbox ECU 12 to determine if there is an incipient lockup of any of the wheels or if at least one of the driven wheel shows a tendency to spin. In this embodiment this is determined by reading the indicators showing whether or not the TCS or the ABS is currently controlling the wheel brakes. If one of the indicators shows that the TCS or the ABS is currently controlling the wheel brakes the method continues with a fourth step S4, else the method continues with a third step S3. In alternative embodiments of the step S2, the incipient lockup or spin tendency may be determined/calculated in other ways or through other means, such as computation by the gearbox ECU 12 based on e.g. the signals received from the speed sensor 16.

In step S3 the computer program for vehicle speed calculation 23 causes the gearbox ECU 12 to calculate an instantaneous vehicle speed based on the signals from the speed sensor 16. Such a calculation is known to a person skilled in the art and is therefore not described in detail. After step S3 the method continues with a fifth step S5, in which the calculated vehicle speed of step S3 is used as an input parameter in a calculation for determining if a gear change shall be initiated. Such a calculation is processed by the gearbox ECU 12 through the computer program for gear shift control 22. After step S5 the method returns to step S1. Tthe vehicle speed and the current gear ratio makes it possible to calculate the engine speed, which in turn is used to determine which gear that preferably should be activated in respect of e.g. economical driving. The computer program for gear shift control may e.g. adapt the gearbox ECU 12 to choose a gear according to a preferred engine speed after a gear shift considering the current vehicle speed.

In step S4 the computer program for vehicle speed calculation 23 causes the gearbox ECU 12 to first calculate a mean value of the rate of rotation for the non-driven wheels 10 and then calculate a vehicle speed based on the mean value, e.g by multiplying the mean value by a known or estimated value of the radius of one of the non-driven wheels. The calculated vehicle speed of step S4 is subsequently used as an input parameter in the calculation of step S5. In another embodiment of step S4, the rate of rotation for one of the non-driven wheels is used for calculating the vehicle speed. In yet an alternative embodiment of step S4, where a value of the vehicle speed ha been received from the GPS signal receiving and processing unit in addition to or instead of the value of the rate of rotation for the non-driven wheels, this GPS based vehicle speed is used as an input parameter in the calculation of step S5. In still another alternative embodiment of step S4, a mean value of the GPS based vehicle speed and the vehicle speed based on the mean value of the rate of rotation for the non-driven wheels 10 is calculated and is used as an input parameter in the calculation of step S5. A further alternative embodiment of step S4, comprises the step of choosing the GPS based vehicle speed, if available. Otherwise the vehicle speed based on the rate of rotation of the non-driven wheels 10 is used. GPS signals from satellites and/or base stations may be unavailable e.g. in cases when the vehicle 1 moves through underground or underwater tunnels, i.e. shadow areas, or among tall buildings causing disturbing reflections. In yet an alternative embodiment of step S4, where a value of the vehicle speed has been received from the vehicle radar system 18, that value is used, either directly as an input parameter in the calculation of step S5, or as one of the values when calculating a mean value based also on the GPS based vehicle speed and/or the vehicle speed based on the rate of rotation of the non-driven wheels 10.

In the embodiments described above, both the situations where a driven wheel is spinning or shows a tendency to spin and where the ABS controls the braking of the vehicle have been considered. It must however be understood that the invention also covers embodiments where only one of the two situations is considered, e.g. embodiments where a step corresponding to the second step S2 above, only comprises determination of whether or not there is an incipient lockup of any of the wheels. An

example of when such an embodiment is suitable is when a vehicle comprises an ABS, but no TCS. Examples of a vehicle where embodiments related only to the determination of whether at least one of the driven wheels are spinning or shows a tendency to spin are applicable, are vehicles comprising a TCS or vehicles having an ABS, but no TCS, together with a gearbox ECU comprising a computer program for determining whether driven wheels are spinning or shows a tendency to spin through received signals from the speed sensor 16. Hence it must be understood that, e.g., the invention is not limited to be implemented in vehicles having an ECU that comprises both ABS and TCS. A vehicle may e.g. comprise an ECU with an ABS computer program and another ECU with a TCS computer program.